The Influence of Videogame Reinforcement Schedules on Game Play Duration

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Statement of Sources

I declare that this report is my own original work and that contributions of others have been duly acknowledged.

Dylan Sault

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Abstract

There are concerns that game developers incorporate structural videogame features designed specifically to maintain play, rather than for reasons such as increased enjoyment. We used a custom videogame to empirically investigate if in-game reinforcement schedules influence videogame playtime. 51 participants (24 female, 27 male), with ages ranging from 18 to 61 years (M = 25.88, SD = 12.31) were randomly allocated to one of three reinforcement conditions: no reinforcement, fixed-interval reinforcement, and variable-interval reinforcement. All participants played a chess-like puzzle game and were instructed to try and complete four available levels, with participants in reinforced conditions also instructed to try and collect all trophies (reinforcements) on a presented list. Importantly, all participants were instructed to only play for as long as they wished. Participants in reinforced conditions played for longer than participants in the control condition (p = .049, d = .76); however, no meaningful difference in playtime was observed between fixed and variable interval conditions (p = .848, d = .07). Results support principles of operant conditioning and provide preliminary evidence that structural videogame features can influence videogame playtime. Limitations concerning power, and implications for free-to-play videogames, awareness of potentially harmful videogame features, and problematic gaming interventions are discussed.

The Influence of Videogame Reinforcement Schedules on Game Play Duration

Videogame playing as a leisure activity has become increasingly popular in many developed countries and has been associated with a variety of benefits, most notably from educational and therapeutic perspectives (Salguero & Moran, 2002). These benefits include the assistance of teaching and learning in educational contexts, aiding patient recovery in medical settings (King, Delfabbro, & Griffiths, 2011), and training applications in workplaces, for example, flight simulators for pilot training (Howard, 2014). In spite of such benefits, there has been concern that heavy videogame play may be problematic. King and Delfabbro (as cited in King et al., 2011, p. 326) defined heavy videogame play as exceeding 30 hours per week, with research linking excessive gaming to a variety of negative outcomes. These outcomes include, but are not limited to, sleep deprivation, reduced productivity, lower academic performance, impaired social functioning and decreased psychosocial wellbeing (King et al., 2011). These findings have prompted research into the mechanisms underlying excessive videogame play. One of the primary focus areas for researchers has been to investigate how structural videogame features influence videogame-playing behaviours. Consequently, the present study aims to investigate the effects of one of behavioural psychology's most well established influences on human behaviour – operant conditioning - within a videogaming context. Specifically, this research investigates the effects of reinforcement schedules – that is, how and when players are rewarded – on the duration of videogame play. Despite the apparent relevance, and many theoretical links between reinforcement schedules and gameplay duration, our review of the published literature suggests that to date, it is an issue that remains unexplored.

Initial research investigating the factors that contribute to videogame play has focused primarily on identifying videogame features that gamers perceive as enjoyable. Research has identified a variety of structural game characteristics that relate to player enjoyment, including realism, character development, game customization features, multiplayer features, and social features (Griffiths, Davies, & Chappell, 2004). Although the structural features reported as enjoyable are likely to contribute to players' desire to play a game, King, Delfabbro, and Griffiths (2010) have suggested that in order to understand the nature of heavy or problematic game play, it is important to understand not just the videogame features that players *report* as enjoyable, but also the structural features of videogames that *influence* playing behaviour.

To provide insight, and guide research, King et al. (2010) proposed a taxonomy of five categories relating to potentially important, structural videogame features. These included social features, manipulation and control features, narrative and identity features, reward and punishment features, and presentation features. Social features relate to the socialising aspects of videogames, for example, features that allow online or offline communication with other gamers, or features that create cooperation, competition or social support (King et al., 2010). For example, online games may incorporate a chartroom that allows players to communicate. Manipulation and control features relate to the in-game features that players can interact with and manipulate in order to gain a sense of mastery and control. This can include the simultaneous management of numerous in-game resources, for example, managing the use of various ammunitions in shooting games, or the ability to save game progress in order to correct mistakes (King et al., 2010). Narrative and identity features also allow player management, specifically in regard to managing their own in-game identity. This refers to the ways in which players can change identities completely, or even take on different fictional constructions of the self (King et al., 2010). Presentation features refer to the aesthetic properties that influence the presentation of a videogame, and thus, how appealing the game is to players. This may relate to graphics (e.g., realism) or sound features such as music, explicit or adult content, in-game advertising, or relations to existing well-known franchises (e.g., *Grand Theft Auto*; King et al., 2010).

Of particular interest to the present study is the category of reward and punishment features (herein referred to as “reward structures”). Reward structures refer to the ways in which players are reinforced or punished for various in-game behaviours (King et al., 2010). Reward structures can take many forms. For example, general reward type features are usually psychological in nature, and may include a virtual currency (e.g., coins), virtual goods, or experience points (“XP”) that allow characters to gain or improve abilities. For example, in shooting games, a gamer may be awarded for kills with money or points, which can be exchanged for weapon upgrades. Usually, these rewards are consistently available throughout a game; meaning players are usually playing to attain numerous reward types concurrently (King et al., 2010). In addition to rewards, punishment features are incorporated to ensure that game progress is to a degree, skill based. Punishment often takes the form of objective failure, level restarts, or the loss of resources such as goods, virtual currency, virtual health, or XP (King et al., 2010). For example, in a shooting game, if a player is killed, rather than having to restart the entire game, they may have to restart from a particular checkpoint, or restart a level. Meta-game rewards provide players with an overall assessment of their playing competency - often by way of a points or percentage rating - by indicating how much of the game a player has completed. An example of this is the Achievement Point system on *Xbox 360*, which rewards players with achievement points for completing certain tasks (King et al., 2010). By incorporating these measures of competency, players are encouraged to continue playing until total competency is achieved (King et al., 2010).

The mechanisms through which videogame reward structures are thought to influence playing time – in particular, excessive playing time - are similar to the mechanisms that influence excessive poker (i.e., slot) machine gambling (Griffiths & Wood, 2000). Griffiths and Wood state that the structural features of poker machines and videogames share similarities on both a psychological and behavioural level. Firstly, poker machines and videogames share high event frequency features – that is, players are able to play many times within a given time period (King et al., 2010). As neither requires continued, uninterrupted play over extended periods to gain reward - for example, the small but regular monetary payments attained from poker-machine gambling, or the rewards attained through completion of smaller tasks or levels in videogames – players can engage in continual, frequently rewarded play, which can result in reduced awareness of game playing time (King et al., 2010).

Secondly, both poker-machines and videogames incorporate near-miss features (King et al., 2010). Near-miss features refer to the perception of a losing event as similar to winning. For example, on a poker-machine, nearly acquiring the pattern of symbols required for a win, or in a skateboarding videogame, nearly landing the final trick in a series of tricks can be reinforcing, as the event is interpreted as nearly winning, rather than as a clear loss (King et al., 2010). Wadhwa and Kim (2015) demonstrated this effect in a videogaming context by manipulating how close participants got to completing a rigged videogame, which required them to guess the location of eight symbols on face-down tiles, from a selection of sixteen tiles. Results indicated enhanced motivation and increased future efforts to win for participants that nearly selected the eight correct tiles (i.e., participants who correctly guessed the location of the first seven, but failed to identify the location of the eighth), compared to participants who selected an incorrect tile on their first guess (i.e., participants who clearly lost). There are also similarities in payout intervals. Specifically, there is little to no interval between the end of a game event and the delivery of a reward in both poker-machines and videogames. Players in both are rewarded immediately following target behaviours, for example, the immediate dispensing of money from a poker-machine, or the immediate awarding of points following a kill in a shooting game (King et al., 2010). The immediate attainment of rewards in the presence of high event frequency allows players to immediately reinvest winnings – such as money in gambling, or virtual currency in videogaming - back into the game. Research has indicated that this results in increased gambling behaviour, due to reductions in time spent processing losses (Delfabbro & Griffiths, 1999). Due to the structural similarities discussed, similar factors may contribute to increased gameplay duration and, potentially, problematic gaming engagement.

Lastly, and most importantly with regard to the present research, poker-machines and videogames are thought to share similarities in terms of the intermittent reward schedules that are used to reinforce behaviours (King et al., 2010). The way in which players respond rapidly and repeatedly to in-game stimuli in gambling, and theorized to occur in gaming, can be explained by operant conditioning theory in terms of a reward structure that follows an intermittent reinforcement schedule – that is, when reinforcement is sporadic as opposed to continuous. Videogames frequently use both fixed (i.e., a fixed number of responses or amount of time between rewards) and variable (i.e. a fluctuating number of responses or amount of time between rewards) reinforcement schedules in order to maintain the players' motivation to acquire in-game rewards and, thus, sustain gameplay for longer periods (King et al., 2010). Research has demonstrated that the intermittent delivery of monetary rewards contributes to the maintenance of habitual poker-machine gambling (Dickerson, 1993; Delfabrro & Winefield, 1999). Logically, based on the similarities between poker-machines and videogames discussed by King et al. (2010), a similar relationship may be expected between the delivery of in-game reward structures and game playing time. Further explanation of operant conditioning, reinforcement schedules and their various applications is detailed below.

Operant Conditioning

Early Research. The observed effects of reward structures on gambling behaviours are unsurprising given the pervasive nature of operant conditioning principles on behaviour modification. Broadly, operant conditioning is a form of incidental learning that occurs through the association made between a behaviour and its consequence. The major premise of operant conditioning - and of Thorndike's (1905) law of effect which heavily influenced early operant conditioning research - is that behaviours that are met with desirable consequences (reinforced) are more likely to be repeated, while those that are met with undesirable consequences (punishment) are less likely to be repeated. This was demonstrated in Skinner's seminal research with a device called the "skinner box" (Skinner, 1950). This device was, in essence, a small cage that featured a lever that a small animal – generally a rat or pigeon – could press in order to receive reinforcement in the form of food or water (Skinner, 1950). By looking at the animals' response rates – that is, how animals responded after pressing the lever - it was apparent that their responses were dependent on the consequences of the action. Specifically, more responses over longer periods occurred when lever presses were reinforced with food, than when they were not reinforced (Skinner, 1950). Further, changing the pattern of reinforcement administration, changed the rate and duration of responses (Skinner, 1950). These patterns of reinforcement administration were to be later known as reinforcement schedules.

Reinforcement Schedules. In both animal and human studies alike, researchers have repeatedly demonstrated that schedules of reinforcement can influence the rate and duration of behavioural responses (Skinner, 1950; Ferster & Skinner, 1957). Reinforcement schedules concern the rules that govern when and how target behaviours are reinforced. There are two basic reinforcement schedule types: continuous and intermittent (Skinner, 1950). Continuous schedules involve reinforcing target behaviours every time that they are performed. In contrast, intermittent schedules take the form of either ratio or interval, with reinforcement becoming available only after a predetermined number of target behaviours have been performed (ratio schedule), or after a predetermined amount of time has elapsed (interval schedule; Skinner, 1950). Two classes of ratio and interval schedules exist - fixed and variable. For fixed schedules, reinforcement can only be attained after a fixed number of target behaviours or time has passed (Skinner, 1950). For example, food rewards might become available for a pigeon in a skinner box after every third lever press (ratio), or for the first lever press following each one-minute period after the presentation of the previous food reward (interval). In contrast, variable schedules operate in much the same way, but instead of the number of target response, or the time interval remaining constant, it is free to fluctuate, so long as the average number of target responses or duration of time intervals remains the same over a sum total of trials (Skinner, 1950). For example, in contrast to the fixed interval example provided previously, for a variable interval schedule, a food reward may become available to the pigeon after the first lever press following a minute, then following thirty seconds, and then following a minute and a half. Whilst the time interval varies, it remains operating on a one-minute average over the three trials.

Research has indicated that different reinforcement schedules are associated with specific characteristic effects (Ferster & Skinner, 1957). In regard to continuous and intermittent schedules, Kendall (1974) revealed that pigeons were more inclined to continually peck a key that resulted in food presentation when the food was presented on an intermittent reinforcement schedule, rather than a continuous reinforcement schedule. Research has consistently demonstrated that intermittent schedules result in steadier response rates, which are more resistant to behavioural extinction than behaviours that are continuously reinforced (Skinner, 1950). This occurs for two main reasons. Firstly, continuous reinforcement can result in satiation (Ferster & Skinner, 1957). Satiation occurs when an organism has received enough of a particular reinforcer to satisfy their needs. For example, continual food rewards will not appeal to an organism that is no longer hungry. If satiation occurs, the behaviour is likely to cease. As intermittent schedules do not continually reward the target behaviour, they are less likely to result in satiation and, thus, response rates remain steady over time (Ferster & Skinner, 1957). Secondly, a change from continual reinforcement, to no reinforcement is easy to discriminate. Thus, if an organism realises a behaviour is no longer rewarded, the behaviour is ceased. In contrast, organisms reinforced on intermittent schedules do not have the expectation that every target behaviour will be rewarded and, thus, even following the removal of a reinforcer, a steady response rate is maintained (Ferster & Skinner, 1957).

Similarly, fixed and variable, and ratio and interval schedules are associated with particular characteristic effects (Ferster & Skinner, 1957). Reward presentation is more predictable on fixed schedules relative to variable schedules, and typically produces a step-like response pattern, where decreases in response rates occur following the presentation of a reinforcer, and increases in response rates occur prior to the presentation of a reinforcer (Lee, Sturmey, & Fields, 2007). In contrast, the more unpredictable nature of variable schedules tends to produce steadier response rates over longer time periods (Lee et al., 2007). Skinner's early operant conditioning research with rats and pigeons demonstrated this pattern, with food rewards on fixed interval schedules producing "post-reinforcement pauses" – ceases in response frequency following the presentation of a reinforcer, as well as responses that were less resistant to behavioural extinction (Ferster & Skinner, 1957). However, variable interval schedules produced an increased, and steadier, rate of responses over longer periods, which were more resistant to behavioural extinction (Ferster & Skinner, 1957).

Ratio and interval schedules are also associated with contrasting characteristic effects (Ferster & Skinner, 1957). Skinner's (1950) research with rats and pigeons, demonstrated that ratio reinforcements typically produce the highest and most consistent rates of responding (Ferster & Skinner, 1957) – effects that have been consistently replicated with humans as well (Lee et al., 2007). This is because the rate of reinforcement is determined by the rate of responses (Ferster & Skinner, 1957). Therefore, if an organism increases the frequency of a target response, they will also increase the frequency at which they receive rewards. As reward delivery is not contingent on the frequency of target responses in interval reinforcement schedules, lower response rates are typically observed (Ferster & Skinner, 1957).

Operant conditioning literature suggests that the behavioural modification effects of interval reinforcement schedules may not be as strong as ratio schedules (Ferster & Skinner, 1957), however, as a sister project is currently researching the influence of ratio schedules on playtime, the present research will focus solely on interval schedules. Consequently, as reinforcing in-game behaviours contingent on playtime, is one of the easiest ways for game developers to reward specific playing behaviours, we wanted to examine if a basic reward structure focused solely on the duration of gameplay (rather than their in-game achievements) can facilitate increases in the duration of play.

Reinforcement Schedules and Gambling. Skinner (1953) theorized that pathological gambling resulted from the partial reinforcement of gambling behaviours. Research into the mechanisms underlying heavy poker machine gambling has highlighted the influence of in-game reinforcement schedules. Poker-machines reinforce players on intermittent schedules of reinforcement (Dickerson, Hinchy, England, Fabre, & Cunningham, 1992). As mentioned previously, research has demonstrated that small, intermittent wins lead to increased response rates over extended periods, whereas larger wins reduce rates of response (Dickerson et al., 1992; Dickerson, 1993; Delfabrro & Winefield, 1999). Therefore, based on the structural similarities between poker-machines and videogames outlined by King et al. (2010), similar response patterns to those observed in poker-machine gambling may also be expected in videogame playing.

Thinning Procedures and Reward Preferences. Research also indicates that gradually reducing reinforcement following target behaviours, can elicit more recurrent stimulus-response patterns (Hagopian, Boelter, & Jarmolowicz, 2011). This form of reinforcement reduction is known as schedule thinning, and is a common feature in videogames (King et al., 2010). In early game stages, target behaviours are met with frequent (and in some cases, continual) reinforcement in order to establish strong behaviour-reinforcer associations. For example, a player may be rewarded in the early stages of a deer shooting game with virtual currency for every deer killed. However, over time, the regularity of reinforcement progressively shifts to more sporadic intermittent reinforcement schedules, where players must produce an increasing number of target behaviours over increased intervals in order to gain reinforcement (King et al., 2010). Using the previously mentioned example, players may have to shoot more deer, over longer, more difficult distances, and within longer time periods in order to receive a reward. Yee (as cited in King et al., 2006) states that in later game stages, acquiring reinforcement can become a "labour of fun", due to the substantial time and effort it requires. Thinning schedules are thought to work – particularly when it is not practical to reinforce target behaviours too frequently - because the gradual reduction in reward frequency ensures that the reward remains valued by the player and, thus, preserves their motivation to obtain it (Hagopian et al., 2011).

The effect of reinforcers on the maintenance of game play may also go beyond the effects of reinforcement schedule alone. Chumbley and Griffiths (2006) found that in the context of videogames, the type of reinforcement used to reinforce target behaviours – that is, positive or negative reinforcement - was associated with differences in game playing behaviours. Specifically, after playing a car racing videogame that required participants to avoid road obstacles, a post-game self-report questionnaire revealed that game levels with increased negative (e.g., removal of road obstacles) to positive (e.g., upgrades in car speed) reinforcement were associated with increased frustration and reduced excitement, whilst levels with an increase in positive to negative reinforcement were associated with a higher propensity to continue and return to gameplay. As Ryan, Rigby, & Przybylski (2006) point out, involvement in gaming environments is largely voluntary, meaning players want to enjoy, and benefit from videogame engagement. Thus, the preference for positive over negative reinforcement may be due to the fact that positive reinforcers are not accompanied with additional unwanted psychological states. For example, in *Grand Theft Auto* (Rockstar Games, 2004) - a game requiring a substantial amount of criminal behavior - flashing sheriffs badges indicate when police are in pursuit. More badges indicate greater police presence. Therefore, reductions in police presence are a negative reinforcer, as they provide relief from an unwanted game state (King et al., 2010). However, the feelings of stress or anxiety – for fear of being caught - that may be present prior to gaining negative reinforcement, is still unpleasant, thus, the unpleasant states associated with negative reinforcement are likely to be less appealing to gamers seeking enjoyment, than positive reinforcement (Ryan et al., 2006). The findings of Chumbley and Griffiths (2006) suggest that if players are positively, rather than negatively reinforced for particular in-game behaviours, the likelihood of continuing gameplay, even following multiple failures, will be increased.

Flow

An additional mechanism through which reward structure might influence gameplay duration is Csíkszentmihaílyi's (2000) concept of flow. Schaffer (as cited in Human Factors International (HFA), 2013) defines flow as the intense and focused concentration on the moment-to-moment experience of a particular activity. The flow experience involves reductions in time awareness (e.g., time appears to be passing faster than normal), a sense of competence in one's ability to respond to challenges within the activity, and the experience of an activity as intrinsically rewarding (HFA, 2013). For flow to be achieved, an activity must meet a variety of conditions. These conditions include ensuring a balance between the challenges of the activity and player skill, and the individual knowing what to do, how to do it, where to go (if navigation is required), and how well they are doing. Lastly, all these conditions must occur within a distraction free environment (HFA, 2013). If these conditions are met, a flow loop is established – that is, users are able to continuously and effortlessly adjust their performance on a given task in response to the challenges faced and the feedback received (HFA, 2013).

Weber, Tamborini, Westcott-Baker, and Kantor (2009) argue that videogames are unique in their ability to satisfy these conditions. They suggest that in particular, the ability to balance the challenges within a videogame with players' ability makes them particularly conducive for stimulating the neural processes responsible for eliciting and maintaining the flow experience (Weber et al., 2009). This is achieved through features that help gamers rapidly acquire the game-related skills and mental models that are necessary for later levels or difficulties. Weber et al. (2009) argues that by increasing game difficulty in combination with a matched skill set, the challenge-skill balance remains congruent, thus, maintaining the conditions necessary to experience flow.

It is therefore reasonable to expect that if videogames are able to elicit flow states, then two consequences of flow may contribute to increased gameplay duration. Firstly, the in-game absorption and reductions in time awareness that occur during flow states (i.e., time appears to pass quickly) may result in an increase in gameplay duration. Secondly, Przybylski, Rigby and Ryan (2010) suggest that according to self-determination theory (SDT), activities must satisfy basic psychological needs in order to produce prolonged engagement. One of these needs is competency, which Przybylski et al. (2010) suggests can be instilled by videogames through the use of positive reinforcement. Thus, if reward structures can contribute to a sense of player competence, then they may also contribute to increases in the duration of game play. Further information on SDT is provided below.

Whilst the present study aims to investigate the influence of reward structure using a videogame specifically designed to have little intrinsic appeal, Schaffer (as cited in HFA, 2013, p. 4) argues that provided the conditional requirements are met, the flow experience is surprisingly consistent across activities, regardless of whether the person considers the activity as play, or even work. Thus, for exploratory purposes, the present study will also examine if reward structures within a videogaming context influence the emergence of flow.

Self-Determination Theory

The importance of feedback to the emergence of flow states, is similarly important to self-determination theory, which Przybylski et al. (2010) suggests is a mechanism through which reward structure may influence game play duration. SDT is principally concerned with the potential for activities to provide experiences that satisfy a variety basic psychological needs (Przybylski et al., 2010). According to cognitive evaluation theory – a sub-theory of SDT – one of the primary basic psychological needs is the need for competence (a need for a sense of self-efficacy; Przybylski et al., 2010). One of the ways that videogames are able to satisfy this need for competency is with the use of performance feedback. Specifically, videogames use reward structures that provide positive feedback (Ryan et al., 2006), for example, general reward features such as points, or direct competency indicators such as meta-game rewards (King et al., 2010) can provide players with a sense of competency, and represents an important element in motivating sustained engagement in videogame play over time (Przybylski et al., 2010). Research by Ryan et al. (2006) indicated that videogames that promote player competence were able to predict an increased preference for future play. This finding suggests that if reward structures contribute to a sense of player competence, then they may also contribute to maintaining the motivation required to persist with gameplay following failures, over extended periods.

Economic Issues: In-Game Transactions

As players want to enjoy their videogaming experience (Ryan et al., 2006), one motivation for the use of in-game structural features is to facilitate this enjoyment by improving the gaming experience. However, a secondary motivation may simply be to increase gameplay duration – independent of enjoyment (Hamari, 2015). If specific structural features are being incorporated into videogames for the purpose of initiating and maintaining long-term play, in contrast to enhancing the playing experience, then research into features such as reward structure is of significant practical importance in the context of free-to-play videogames. Free-to-play videogames are games that can be acquired free of charge, but encourage players to make small, but regular, in-game transactions, in order to attain additional in-game features such as virtual currency, goods, or features, that allow more rapid game progress (Alha, Koskinen, Paavilainen, Hamari, & Kinnunen, 2014).

Hamari (2015) found that intention to play free-to-play videogames was positively associated with the intension to purchase these additional features, however, enjoyment was negatively associated. Hamari (2015) suggests that if a videogame is sufficiently enjoyable, players have little incentive to purchase additional in-game features. However, if original videogame versions are released with particular flaws in functionality, a demand for these features can be created (Hamari, 2015). Thus, if reward structures can encourage intention to play, without directly increasing enjoyment, players may be more likely to purchase the additional in-game features needed for improved functionality. This is both an economical and ethical concern, as free-to-play videogames are widely available on a range of readily accessible platforms such as mobile phones (e.g., *Candy Crush Saga;* Alha et al., 2014) and social networking services (e.g., *FarmVille;* Alha et al., 2014), making it possible to exploit all gamers, including those that may be intellectually impaired, or even children.

The Present Research

Whilst many theoretical links have been established between videogame reward structures and playing behaviour – the majority being drawn from gambling literature - there has been limited empirical testing to investigate this link within a videogame context. More precisely, although we assume game companies have invested substantial amounts of money in investigating these issues, there is little to no empirical consideration of these issues in the peer-reviewed scientific literature, or in the public domain. Although King et al. (2011) found, based on participants' self-reports, that reward delivery features have the greatest influence, and are the strongest predictors of problematic videogame play - over and above factors such as age, gender or videogaming frequency - no research to date has experimentally examined videogame playing behaviours in response to specific manipulation of in-game reinforcement schedules.

The present study used a custom videogame (*Knight's Tour*), and three contrasting reward structures: no reinforcement (control), fixed-interval-thinning reinforcement, and variable-interval-thinning reinforcement, to empirically investigate if the manipulation of in-game reward structures influences the duration of videogame playtime. As the present research is part of a broader research project, the focus of this study related specifically to the influence of interval reinforcement schedules on playtime, whilst a second researcher focused on the influence of ratio schedules. By using our custom videogame, *Knight's Tour*, we were able to provide a videogame with very limited intrinsic appeal to the gamer. By doing this, we excluded a number of confounding variables that may be present in existing videogames that may potentially influence gaming behaviours. For example, factors that may contribute to enjoyment, such as game customization features, multiplayer features, and social features (Griffiths et al., 2004) are avoided. Although this approach sacrifices elements of ecological validity (games are generally not designed to minimise intrinsic appeal), it allowed us to isolate the effects of contrasting reward structures on playtime. Thus, it represents an initial step in the investigation of the effects of reward structures on gameplay duration and, potentially, problematic gameplay.

Based on the patterns and duration of responses that have been observed in operant conditioning and reinforcement schedule research (Skinner, 1950; Ferster & Skinner, 1957; Lee et al., 2007, Kendall, 1974; Chumbley & Griffiths, 2006; Hagopian et al., 2011), we hypothesised that reinforced conditions (fixed and variable interval thinning schedules) would elicit longer periods of playing time than the control condition (no reinforcement), and the variable-interval-thinning condition would elicit longer periods of playing time than the fixed-interval-thinning condition.

In addition to investigating the influence of reward structure on playtime, we also examined if reward structure influenced the number of level restarts following failure. This measure serves as an index of persistence.

For exploratory purposes, we also wanted to see if reward structures contributed to the emergence of flow, which may in turn, lead to increased gameplay. Again, for exploratory purposes, we also wanted to see if gaming frequency moderated the effect of reward structure on playtime, level restarts and flow, as research has indicated differences in the effect of reinforcement schedules in frequent and non-frequent gamblers (Dickerson, 1993).

Method

Ethics Approval

A minimal risk ethics application was submitted and approved (Ethics Reference number: H0014954) on the 22nd of May 2015 by the Human Research Ethics Committee (Tasmania) Network (see Appendix A).

Participants and Design

51 participants (24 female, 27 male), with ages ranging from 18 to 61 (M = 25.86 years, SD = 12.32 years) were randomly allocated to the three experimental conditions: no reinforcement (control group), a fixed-interval-thinning reinforcement schedule, and a variable-interval-thinning reinforcement schedule (17 per condition). Participants were drawn primarily from the broader Hobart community and compensated with a $15 voucher for their time. Also, a small number of participants were first-year psychology students who were awarded course credit for their participation. Three participants self-identified as frequent gamers. The proportion of frequent gamers did not differ across conditions.

Analysis

The key dependent measure was total game playtime, measured in milliseconds (msec). Additional dependent measures included total level restarts and flow. To directly test hypotheses, planned comparisons were used to compare group means between control and experimental conditions, and between fixed and variable interval conditions on each dependent measure.

Materials

The game. Participants played a custom videogame (*Knight's Tour*), allocated to one of the three contrasting reinforcement conditions. This game required participants to select a starting square on a five by five grid, and then move around the grid in the shape of a chess "Knight" (two blocks vertical and one block horizontal, or vice versa), attempting to land on every square no more than once. Participants moved their icon around the grid by clicking a mouse on the square that they wished to land on. If an incompatible square were selected (i.e., a square that cannot be landed on with a Knight shaped moved), the icon would remain where it was. If participants successfully "cleared a board", they advanced to the next level (i.e., a larger grid). Subsequent grid sizes consisted 6×6, 8×8, and 10×10.

Meta-Game Rewards. Rewards were administered for experimental conditions using meta-game rewards in the form of in-game, *Steam* (an internet-based gaming platform) style trophies, designed using an online achievement generator (says-it, 2015). Trophies consisted of the "Block Breaker Trophy" and the "Persistence Trophy" (see Appendix B). These trophies were awarded contingent on specific intervals of gameplay. Specifically, a trophy was only awarded once a response was entered (i.e., selecting a square) after a given time interval had passed. This was to avoid a situation where participants could sit and do nothing, and still accumulate trophies. A “First Steps Trophy” and a “Level Completion Trophy” (1-4; see Appendix B) were awarded to all participants in experimental conditions for selecting a first square, and completing each level, respectively, to accurately replicate the reward features of videogames. Further information on each of the reward structures is detailed below.

In the fixed interval condition, the Block Breaker Trophies were delivered in four groups of five trophies: 5 x *Block Breaker Bronze* delivered every 20 seconds, followed by 5 x *Block Breaker Silver* delivered every 30 seconds, followed by 5 x *Block Breaker Gold* delivered every 50 seconds, and finally, 5 x *Block Breaker Platinum* delivered every 80 seconds. As can be seen, as per “schedule thinning”, the Block Breaker Trophy was thinned (increased intervals between rewards) by an additional 10sec after every trophy stage (i.e., increased by 10 seconds from bronze to silver, 20 seconds from silver to gold, and 30 seconds from gold to platinum). The Persistence Trophy consisted of four trophies delivered on a three minute schedule: *Persistence Trophy Bronze, Persistence Trophy Silver, Persistence Trophy Gold*, and *Rick Astley Persistence Levels: Never Gonna Give You Up Trophy.* As per schedule thinning, the interval between rewards was thinned by 30 seconds after every trophy.

In the variable interval condition, the Block Breaker trophies were delivered on the same interval schedule, on average, within each of the four groups of five trophies (i.e., 20, 30, 50, and 80 seconds). However, the time between each individual trophy was free to fluctuate, so long as the average duration between each trophy remained the same as the fixed interval condition, within each group of five trophies. For example, in the fixed interval condition, the *Block Breaker Bronze Trophy* (1-5), was presented on a 20 second fixed schedule, thus, was available after 20, 40, 60, 80 and 100 seconds. In contrast, in the variable condition, the same trophies were available after 30, 40, 70, 90 and 100 seconds. Here, the intervals between trophies fluctuate, but on average, are still available every 20 seconds. The Persistence trophies were delivered on the same three-minute schedule, and, as per schedule thinning, were thinned by 30 seconds after every trophy. The exact time that each trophy was available after is provided (See Appendix C).

Frequency of Videogame Play Survey. King et al.'s (2011) *Frequency of Videogame Play Survey* questionnaire (See Appendix D) was used to examine weekly videogame playing frequency – more specifically, to determine frequent gamers vs. non-frequent gamers. This instrument allowed participants to report their frequency of videogame play – based on the last three months, for each day of the week, across five different videogame systems: computer, console, mobile phone, handheld gaming device, and arcade machine. King et al. (2010) state that this method is not immune to self-report error, however, breaking down game play by day and by videogame system may aid recall by encouraging participants to think about the many different videogames they may be playing and when This method of recall avoids abstract estimations based on a "typical sitting", and by adding all values within the matrix, allows an overall, weekly number of hours spent playing videogames to be obtained (King et al., 2010).

Instructions. Two sets of instructions were given that differed between the control and reinforced conditions. The control condition was told to "try and complete all four levels, but note, that you only have to play for as long as you wish. There are no time requirements or performance expectations." In contrast, the reinforced conditions were told to "try and complete all four levels, and collect all the trophies in the Trophy Cabinet, but note, that you only have to play as long as you wish. There are no time requirements or performance expectations."

Flow Condition Questionnaire: Schaffer's (HFI, 2013) Flow Condition Questionnaire (FCQ; See Appendix E) was used as a measure of the conditions required to achieve flow. The FCQ is a seven-item questionnaire, where participants must indicate on a five-point Likert scale their frequency of knowing on four items (1: Never; 3: About half the time; 5: Always), and strength of feeling on three items (1: Not at all; 5 Very much).

Procedure

Participants were presented with an information sheet outlining the general purposes of the study, and a briefing of their role as participants (See Appendix F). The specific hypotheses and research questions under investigation were not disclosed to participants to ensure that response patters were not altered (i.e., preventing socially desirable responses or responses related to the participants' perceptions of the experimenter's expectations), thus, preserving the validity of the behavioural measures. After completing an informed consent form (See Appendix G), participants were assigned to either the control, fixed interval, or variable interval conditions by order of arrival (i.e., first participant: control, second participant: fixed interval, third participant: variable interval etc.). Participants then completed the *Frequency of Videogame Play Survey* (See Appendix D; King et al., 2011). Following this, participants were presented with an instruction guide for *Knight's Tour* (See Appendix I) that outlined how to play, as well as the aim of the game. In experimental conditions, participants were also presented with the *Knight's Tour Trophy Cabinet* - a list of all the available trophies (See Appendix B). Participants were instructed to aim to complete the four available levels (and for experimental conditions, collect all trophies) but to only play for as long as they wish. Total playtime (milliseconds) and total number of level restarts was recorded. Shortly after play has ceased, participants completed Schaffer's (HFI, 2013) FCQ (See Appendix E), with reference to their experiences and perceptions of the *Knight's Tour* game. Following completion of the FCQ, participants were thanked for their participation verbally debriefed, and presented with a debriefing form (see Appendix I).

Results

Data Screening

Prior to running analyses, playing time, restarts and flow data were screened for the presence of outliers. Outliers were defined as data points greater or less than 3.29 standard deviations from the mean (Tabachnick & Fidell, 2007). No outliers were identified in the data set. However, data screening revealed a positive skew (skewness = 1.32, SE = .33) in the playing time data, so a square-root transformation was performed to normalise the data.

Playing Time

Planned comparisons were conducted to compare the effect of reward structure (no reinforcement, fixed interval, variable interval) on playing time. The moderate, approaching large effect of reward structure, $t(48) = 2.02$, $p = .049$, $d = .76$ indicated that participants in reinforced conditions played for significantly longer than participants in the control condition (M = 1012.01$msec_{sqrt}$, SD = 290.91$msec_{sqrt}$, 95% confidence intervals (CI) [862.44$msec_{sqrt}$, 1161.59$msec_{sqrt}$]). However, no statistically significant difference was observed between the fixed interval condition (M = 1230.41$msec_{sqrt}$, SD = 384.65$msec_{sqrt}$, 95% CI [1032.64$msec_{sqrt}$, 1428.18$msec_{sqrt}$]) and variable interval condition (M = 1207.64$msec_{sqrt}$, SD = 352.60$msec_{sqrt}$, 95% CI [1026.35$msec_{sqrt}$, 1388.92$msec_{sqrt}$]), $t(48) = .19$, $p = .848$, d = .07. For ease of interpretation, we also report mean playing time data in seconds (see Table 1), in addition to the previously reported square root transformed data.

Table 1

Means and 95% Confidence Intervals for Dependent Measures by Condition

	Reward Condition		
	Control	Fixed	Variable
		Playing Time ($msec_{sqrt}$)	
M	1012.01	1230.41	1207.64
95% CI	[862.44, 1161.59]	[1032.64, 1428.18]	[1026.35, 1388.92]
		Playing Time (sec)	
M	1103.82	1653.16	1575.39
95% CI	[775.44, 1432.21]	[1145.46, 2160.87]	[1072.87, 2077.92]
		Level Restarts	
M	21.24	30.41	27.24
95% CI	[16.58, 25.89]	[21.33, 39.49]	[18.54, 35.93]
		Flow	
M	23.24	22.94	24.59
95% CI	[20.63, 25.84]	[20.88, 25.00]	[22.22, 26.95]

Level Restarts

Planned comparisons were conducted to compare the effect of reward structure on the number of level restarts. No statistically significant difference between the control and reinforced conditions was observed, $t(48) = 1.70$, $p = .096$, $d = .49$. However, the borderline moderate effect of reinforcement suggests that participants in reinforced conditions were more likely to re-attempt a level following failure than participants in the control condition (see Table 1; $M = 21.24$, $SD = 9.06$, 95% CI [16.58, 25.89]). The absence of a statistically significant difference between group means may reflect a lack of power due to insufficient sample sizes. No statistically significant difference between the fixed interval condition (*M* = 30.41, *SD* = 17.66, 95% CI [21.33, 39.49]) and variable interval condition (*M* = 27.24, *SD* = 16.91, 95% CI [18.54, 35.93]) was observed, $t(48) = -.62$, $p = .541$, $d = .18$.

Flow

Planned comparisons were conducted to compare the effect of reward structure on flow. No statistically significant difference between the control (*M* = 23.24, *SD* = 5.07, 95% CI [20.63, 25.84]) and reinforced conditions was observed (see Table 1), $t(48) = .39$, $p = .699$, $d = .11$. Similarly, no statistically significant difference between the fixed interval condition and variable interval condition was observed, $t(48) = 1.04$, $p = .299$, $d = .30$. However, a small effect size indicates that the variable interval condition (*M* = 24.59, *SD* = 4.60, 95% CI [22.22, 26.95]) may elicit slightly higher flow ratings than the fixed interval condition (*M* = 22.94, *SD* = 4.01, 95% CI [20.88, 25.00]).

Frequent vs. Non-Frequent Gamers

Tests examining if gaming frequency moderated the effect of reward structure on playtime, level restarts and flow were not included in the analysis, as an insufficient number of frequent gamers were obtained during participant recruitment.

Discussion

We investigated the effects of reward structure on gameplay duration, number of level restarts, and flow. Reward structure significantly affected game play duration between control (no reinforcement) and experimental (reinforced) conditions. As hypothesised, on average, participants in experimental conditions engaged in significantly longer game playing periods than participants in the control condition. In contrast to our hypothesis, the type of reward structure used did not significantly affect game play duration (no difference was evident between the fixed and variable interval conditions). Based on examination of effect sizes, reward structure appeared to also affect the number of level restarts between the control and experimental conditions. In line with expectations, participants in experimental conditions were more likely to re-start levels following failure than participants in the control condition. However, due to a lack of power this contrast did not reach statistical significance. Further, similar to the findings observed for playtime and in contrast to our hypothesis, reward structure did not affect the number of restarts between fixed and variable interval conditions. Lastly, whilst reward structure did not affect flow ratings between the control and experimental conditions, a small, albeit non-significant effect was observed between the fixed and variable interval conditions. This finding again, is likely to reflect a lack of power.

These findings reflect both consistencies and inconsistencies with our major underlying theoretical framework - operant conditioning theory. The observed increases in game playing time and level restarts in reinforced conditions relative to the control are consistent with Thorndike's (1905) well established law of effect, as well as the robust conditioning effects of operant conditioning theory, that have been consistently demonstrated across a variety of domains (Skinner, 1950; Ferster & Skinner, 1957; Lee et al., 2007, Kendall, 1974; Chumbley & Griffiths, 2006; Hagopian et al., 2011). These findings suggest that behaviours that are reinforced tend to be reproduced more frequently, and sustained over longer periods than behaviours that are not reinforced. The increases in playing time and level restarts observed in reinforced conditions, also lends support to the idea that a psychological need for competence – as outlined by self-determination theory - may be one of the mechanisms through which reward structures can influence gameplay duration and persistence. The use of meta-game rewards – a director indicator of competence – may have helped maintain players' motivation in the face of multiple failures and, thus, resulted in increased playtime and persistence relative to the control condition.

Interestingly, the absence of any meaningful difference in game playing time and level restarts between fixed and variable interval conditions are a surprising inconsistency with theory concerning schedules of reinforcement (Ferster & Skinner, 1957). Due to the relatively unpredictable nature of reward presentation in variable interval schedules (compared to fixed interval schedules), increased response rates over longer periods are typically observed during variable schedules. In contrast, the more predictable fixed interval schedules typically produce post-reinforcement pauses, and behaviours that are less resistant to behavioural extinction (Ferster & Skinner, 1957). Two possible explanations for these findings are considered.

Firstly, the total length of the reward schedules may have prevented any meaningful difference between the fixed and variable interval conditions from emerging. For the fixed and variable interval schedules, mean playing time was 1230.41 and 1207.64 seconds respectively. However, in both conditions, the meta-game rewards that were functioning as a part of the two concurrently running reward schedules, ended after approximately 900 seconds of gameplay. Whilst some slight differences in the timing of the final meta-game reward would have occurred due to discrepancies in participant response rates (participants did not receive a trophy following an elapsed time interval until they selected the next square) all participants in experimental conditions would have obtained the final available trophy at a similar time. As indicated by the means, playing time in the experimental conditions continued following the final obtained trophy. This suggests that behavioural extinction - the weakening in the frequency of a reinforced response, once the reinforcement for that response has been removed (Skinner, 1950) - may have occurred. Therefore, it is possible that if the reward structures ran for similar times in the experimental conditions, and the final trophy was obtained at a similar time for all participants, then behavioural extinction could have occurred at a similar rate following the cessation of reward presentation. Consequently, if behavioural extinction began at a similar time, and occurred at a similar rate, then similar mean playing times and level restarts would be observed between experimental conditions. If the reward structure was lengthened so as to remain present even after prolonged playing times, such potential behavioural extinction effects may have been prevented – or at least delayed, resulting in a more pronounced difference between fixed and variable interval conditions.

A secondary explanation for these findings concerns the relative intrinsic importance of obtaining the meta-game rewards, compared to the importance of completing levels within the game. Studies focusing on the influence of reward schedules have generally focused on rewards associated with a given schedule as being the primary means of behavioural reinforcement (Skinner, 1950; Ferster & Skinner, 1957; Kendall, 1974; Dickerson et al., 1992; Chumbley & Griffiths, 2006). For example, in animal studies, behavioural reinforcement typically takes the form of food, and these food rewards are the primary motivation for animals to reproduce target behaviours (Skinner, 1950; Kendall, 1974). Similarly, for poker machine players, behavioural reinforcement takes the form of monetary rewards, with the financial gain associated with these rewards being the primary motivation for gamblers to continue gambling (Delfabbro & Winefield, 1999). However, in this study, the completion of levels was likely to be the primary motivation for players. Achieving the available meta-game rewards was possibly a secondary and less important goal, due to the limited intrinsic appeal of the trophies, and the limited value they had for the player. For example, the trophies were unlikely to enhance player enjoyment, did not present any functional in-game benefits (e.g., could not be used to or exchanged for additional in-game progress or ability), and did not present any social benefits, such as progress, ability, or in-game status relative to other players. Some participants also informally reported that they noticed the trophies popping up, however, did not actually attend to them (i.e., read or look at them). The nature of these reward structures as a secondary motivation, combined with their limited intrinsic appeal and value, may have resulted in a reward structure that was stronger than none at all, but too weak to produce the differences between fixed and variable interval conditions that would be typically expected (Ferster & Skinner, 1957). If game progression was contingent on players obtaining these reward structures (i.e., level progression can only occur once a certain number of rewards are obtained), and less importance was given to the possibility of level advancement without obtaining these rewards, then more typical reinforcement schedule effects would be seen.

As Weber et al., (2009) had suggested that videogames were unique in their ability to satisfy the conditions required for flow, for exploratory purposes, we wanted to examine if reward structure contributed to the emergence of flow. Interpreting the effect of reward structure on flow is challenging. The small effect of reward structure observed between fixed and variable interval conditions is difficult to interpret in light of the absence of a meaningful difference between the control and reinforced conditions. It is important to acknowledge that Schaffer's (HFI, 2013) FCQ was developed as a measure of the conditions required to achieve flow, but was not designed to yield an overall flow score as it was used here, nor was it intended for use with videogames specifically. More specifically, many participants informally reported some difficulty interpreting the questionnaire items within the context of the Knight's Tour videogame. For example, some questions could be interpreted in multiple ways, such as the question "how much of the time did you know how to do what you were doing?" This question could relate to whether or not the player knew the aim of the game, how to operate the controls (i.e., how to select a square using the mouse), or how tactically, they could complete a level. Thus, the use of a questionnaire not specifically designed for use in this domain may be a limitation of this study. However, it is worth nothing that even with an assessment tool that was not ideally suited to the measurement of flow in this context, the small effect size observed between fixed and variable conditions suggests that the nature of reward structures may affect the facilitation of a flow state and, therefore, is a mechanism worthy of further investigation. Thus, while the present study is unable to provide a clear and definitive explanation for the relationship between reward structure and flow, the results obtained - purely for exploratory purposes - suggest that flow, and its relation to reward structure and videogame playing behaviours is a topic that future research should consider.

The present findings provide some initial insights into the psychological mechanisms underlying game playing behaviours, specifically, those that may contribute to heavy or even problematic gaming. The increases in playing time and level restarts observed in reinforced conditions, in response to a reward structure with minimal intrinsic appeal are consistent with the views of King, Delfabbro, and Griffiths (2010). That is, to gain a holistic understanding of the factors influencing excessive gameplay, it is important to understand not just the videogame features *reported* by players as enjoyable, but also the structural features of videogames that *influence* playing behaviours. It appears based on these findings that reward structures are one particular structural feature that contributes to the maintenance of videogame play and, thus, may be a contributing factor to the development of heavy, and problematic styles of videogame play. From an applied perspective, a thorough understanding of the mechanisms underlying problematic videogame play is essential if education and intervention strategies are to be developed in this area.

In addition to understanding structural game factors related to increased playing duration, the observed effects of reward structure may also have implications for another potentially problematic aspect of gameplay: in-game transactions. In-game transactions are usually small financial payments that are prompted during the course of gameplay, that provide players with virtual goods, currency, or additional features, and are a common feature of free-to-play video games (Alha et al., 2014; Hamari, 2015). If reward structures are able to elicit increases in both playing time and persistence following failure, and potentially contribute to excessive or problematic gaming behaviours, then in line with Hamari's (2015) findings, increased exposure to these structures could also result in an increased intension to spend money on free-to-play game features. Restrictions enforced on playtime, and how frequently levels can be attempted are a common feature of many free-to-play games (e.g., *Candy Crush Saga*; Alha et al., 2014), and may work in opposition to reward structures that can increase a player's willingness to play for longer periods, and persist following failures. Consequently, it is possible that the conflict created from an increased willingness to play, but a restricted ability to do so, may increase players' willingness to pay for the additional access or content required for more rapid game advancement. By creating this conflict, game developers may be able to increase intention to play – a factor linked to an increased intention of making in-game purchases (Hamari, 2015) - without increasing enjoyment to excessive levels – a factor linked to a reduced intention of making in-game purchases (Hamari, 2015). Therefore, as seen in gambling, the influence of reward structure on in-game transactions may have a variety of economic consequences for the player. Whilst this is only speculative at present, this research represents an initial step in understanding the way in which reward structures may be related to in-game transactions.

It would be remiss not to acknowledge some important limitations of this research. Firstly, we recruited fewer participants than originally intended, which resulted in reduced statistical power. It appears that the 51 participants (17 per condition) involved in this research were not sufficient. In order to reveal the small effect of reward structure on playtime and level restarts between fixed and variable interval conditions at a statistically significant level, a larger sample size would be required. Secondly, there are also limitations in regard to our neglect of ability and performance. For example, if obtaining reinforcement was contingent on performance rather than duration of play – that is, reinforcement can only be attained if the player is able to perform successful target behaviours, or demonstrate a specific level of competency within the game - then differences in gameplay duration and level restarts may have been observed between players of different abilities. Similarly, players with greater ability are likely to have performed better, thus, are likely to have been closer to completing levels more often than those with lesser ability. As a result, it is likely that better players' proximity to level completion would result in them experiencing more near-misses, which as a result, can encourage players to continually return to play following failed attempts (King et al., 2010; Wadhwa and Kim, 2015). Our failure to effectively measure ability, performance, or the presences of near misses means that caution should be taken when interpreting these findings. However, it is important to note that random allocation should have washed out any individual differences in ability or performance between conditions. There are also some questions over the ecological validity of this research. A game with the simplicity of *Knight's Tour* would be better suited to a touch screen, mobile phone style of videogame, as opposed to the PC style of game that it was played as. Generally, these basic puzzle style mobile phone games are more often played from the comfort of a couch, in addition to activities requiring little demand on attention (e.g., listening to music, waiting for dinner to cook), rather than on a computer at a desk in a silent room. The testing conditions used in this research may not have been appropriate for the style of game being used. Thus, the reduced comfort of the testing conditions may have resulted in shorter playing times than what may be observed if participants were to play *Knight's Tour* in a more ecologically valid setting. It is important to note that even participants in the control condition played for 1103.82 seconds (approximately fifteen minutes). So while this concern over ecological validity is important to acknowledge, it was unlikely to be a major issue, and we have no reason to suspect that it influenced differences in gameplay duration between conditions.

By gaining a preliminary understanding of how reward structure may contribute to gameplay duration and persistence following failure, we also begin to understand how these structural game features may contribute to the development of problematic gameplay and its associated negative outcomes. Future research in this area can expand upon the current findings by investigating the influence of reward structure in further depth. Currently, these findings are somewhat limited to the game and reward type used in the present study. Future research could consider the influence of other, or even multiple reward types on gameplay duration. This may include the effect of general reward features such as XP points, or virtual currency that can be exchanged for various goods or features, or investigate whether positive and negative reinforcement, and punishment, exert different effects on gameplay duration and persistence. An issue that also requires additional research is how reward structures interact with the structural features that influence players' intrinsic motivation to play, and how these interactions influence gaming behaviours. Specifically, investigation may focus on how reward structures interact with factors that facilitate player enjoyment, for example, multiplayer features, game customization features, or features relating to realism such as graphics and sound (King et al., 2010).

At present, the findings of this research are preliminary, but offer initial insights into the way reward structures can affect gameplay duration and persistence. Specifically, the present research has potential implications for understanding the mechanisms underlying problematic gaming behaviours, as well as the factors that may contribute to in-game financial transactions observed in free-to-play videogames. Further research in this area will provide greater understanding within the public domain of how in-game structural factors interact, and influence gaming behaviours. In turn, this information may be used to educate both prospective and current gamers of the potentially harmful effects of specific videogame features and, consequently, may be used to inform interventions designed to assist those that engage in problematic videogame play.

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Appendix A

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HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

UTAS

22 May 2015

Dr Jim Sauer
Psychology
Private Bag 30

Sent via email

Dear Dr Sauer

Re: MINIMAL RISK ETHICS APPLICATION APPROVAL
Ethics Ref: H0014954 - The Influence of Video Game Reinforcement Schedules on Game Play

We are pleased to advise that acting on a mandate from the Tasmania Social Sciences HREC, the Chair of the committee considered and approved the above project on 21 May 2015.

This approval constitutes ethical clearance by the Tasmania Social Sciences Human Research Ethics Committee. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approval of other bodies or authorities is required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

Please note that this approval is for four years and is conditional upon receipt of an annual Progress Report. Ethics approval for this project will lapse if a Progress Report is not submitted.

The following conditions apply to this approval. Failure to abide by these conditions may result in suspension or discontinuation of approval.

1. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval, to ensure the project is conducted as approved by the Ethics Committee, and to notify the Committee if any investigators are added to, or cease involvement with, the project.

2. Complaints: If any complaints are received or ethical issues arise during the course of the project, investigators should advise the Executive Officer of the Ethics Committee on 03 6226 7479 or human.ethics@utas.edu.au.

3. Incidents or adverse effects: Investigators should notify the Ethics Committee immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Amendments to Project: Modifications to the project must not proceed until approval is obtained from the Ethics Committee. Please submit an Amendment Form (available on our website) to notify the Ethics Committee of the proposed modifications.

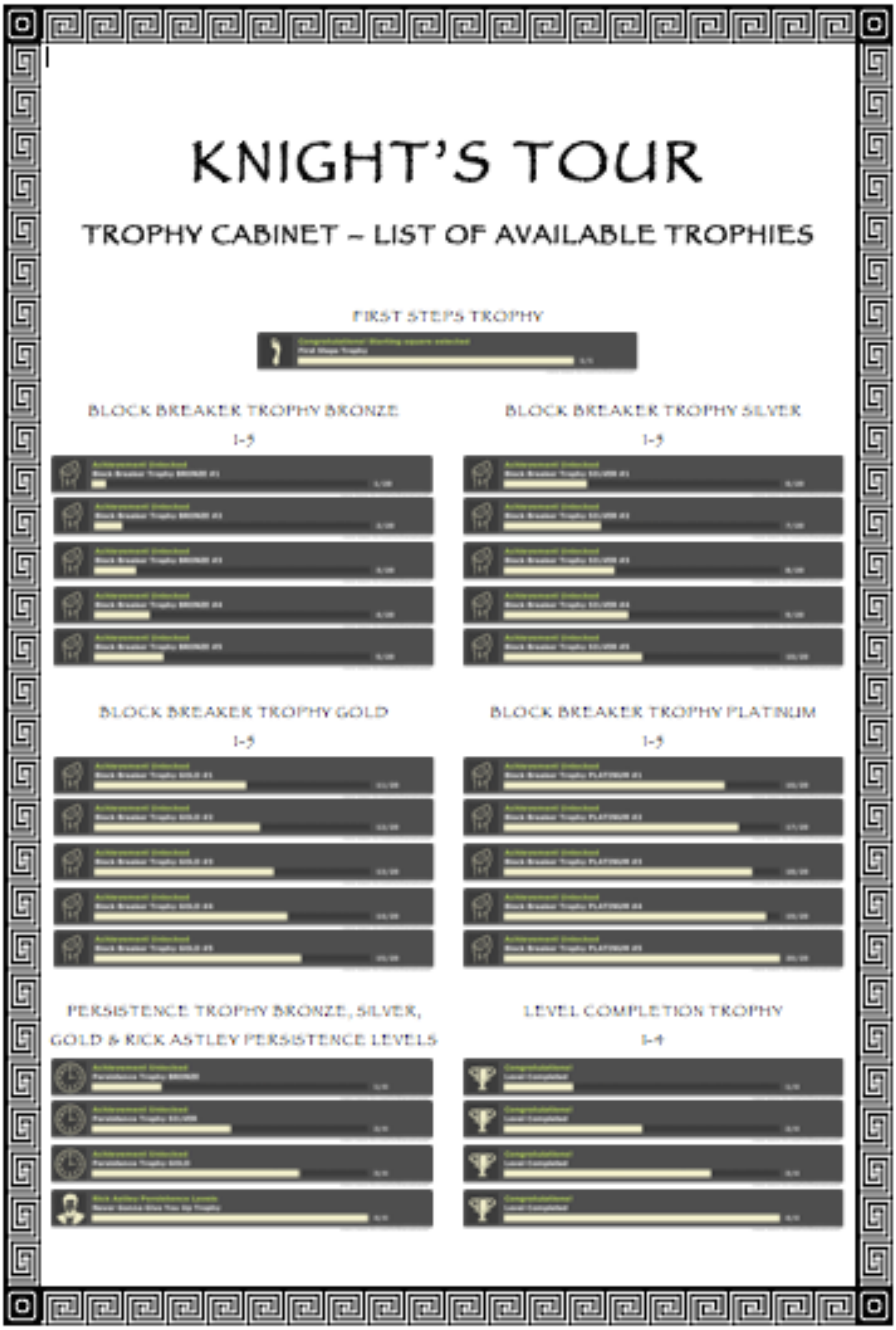
5. Annual Report: Continued approval for this project is dependent on the submission of a Progress Report by the anniversary date of your approval. You will be sent a courtesy reminder closer to this date. **Failure to submit a Progress Report will mean that ethics approval for this project will lapse.**

6. Final Report: A Final Report and a copy of any published material arising from the project, either in full or abstract, must be provided at the end of the project.

Yours sincerely

Natasha Jones
Ethics Officer
Tasmania Social Sciences HREC

Appendix B


KNIGHT'S TOUR
TROPHY CABINET – LIST OF AVAILABLE TROPHIES
FIRST STEPS TROPHY
BLOCK BREAKER TROPHY BRONZE
1-5
BLOCK BREAKER TROPHY SILVER
1-5
BLOCK BREAKER TROPHY GOLD
1-5
BLOCK BREAKER TROPHY PLATINUM
1-5
PERSISTENCE TROPHY BRONZE, SILVER,
GOLD & RICK ASTLEY PERSISTENCE LEVELS
LEVEL COMPLETION TROPHY
1-4

Appendix C

Table 2

Time of Reward Availability by Experimental Condition

	Reward Condition	
	Fixed	Interval
Trophy	Availability of Reward (total seconds)	
Block Breaker Bronze		
1	20	30
2	40	40
3	60	70
4	80	90
5	100	100
Block Breaker Silver		
1	130	150
2	160	170
3	190	210
4	220	220
5	250	250
Block Breaker Gold		
1	300	280
2	350	320
3	400	410
4	450	470
5	500	500

Table 2 continued

Block Breaker Platinum		
1	580	600
2	660	650
3	740	670
4	820	750
5	900	900
Persistence Bronze	180	180
Persistence Silver	390	390
Persistence Gold	630	630
Rick Astley Persistence	920	920

Note. "Availability of reward" indicates the amount of seconds, from the beginning of the game until a trophy became available

Appendix D

Frequency of Video Game Play Survey

Based on your video game play in the last three months, please indicate approximately how many hours per day you would typically play video games on each of the following gaming systems, for each day of the week.

If your video game play per day is less than 1 hour for any of the following gaming systems, please indicate approximately how many minutes per day you would typically play for.

	Computer	**Console** (e.g., *PlayStation, Xbox)*	**Mobile Phone** (e.g., *Candy Crush, Snake)*	**Handheld Device** (e.g. *Gameboy, Nintendo DS)*	**Arcade Games** (e.g., *Big Buck Hunter)*
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					

Appendix E

Flow Condition Questionnaire (FCQ)

Owen Schaffer

Please indicate how much of the time you knew each of the following while you were doing the activity by marking one circle for each question.

How much of the time did you know ?

	Never		About half of the time		Always
what to do next	O	O	O	O	O
how to do what you were doing	O	O	O	O	O
how well you were doing	O	O	O	O	O
where to go next	O	O	O	O	O

Please answer the following questions about how you felt **while you were doing the activity** by marking one circle for each question.

	Not at all				Very much
How challenging did this activity feel?	O	O	O	O	O
How much did you feel able to overcome the challenges you faced?	O	O	O	O	O
How distracted were you from what you were doing?	O	O	O	O	O

Appendix F

The Influence of Video Game Features on Video Game Playing Behaviours

Information Sheet for Participants

1. Invitation

You are invited to participate in a study aimed at understanding the effects of videogame features on game playing behaviour. The study is being completed as partial fulfillment of a Psychology Honours degree at the University of Tasmania by student researchers, James Thomas and Dylan Sault, under the supervision of research supervisor, Dr. Jim Sauer.

2. *What is the purpose of this study?*

This study investigates how videogame features influence game-playing behaviour and experiences. However, the exact aims and hypotheses of this study will be withheld from you until the data collection process is complete. This is to ensure that knowledge of the study aims and hypotheses do not influence you or your responses during testing.

3. Why have I been invited to participate?

You may have been invited for a number of reasons. You may have been invited on the basis of your enrollment in the Bachelor of Psychology program at the University of Tasmania. Participation in this study will contribute to postgraduate students' research projects, and contribute to first year student's course credit. Your participation in this study is entirely voluntary. There are no consequences should you chose not to participate. Should you choose to participate in this study but change your mind during your participation, you are able to withdraw at any time without penalty.

You may also be here because you responded to advertising placed around campus, or because your name is on a list of people who wish to be contacted about research participation opportunities.

In any case, your participation in this study is voluntary – you are entirely free to choose to participate or not, and there will be no consequences if you decide not to participate. If you do participate, any information you provide will be anonymous and no participants in the experiment will be individually identifiable.

What will I be asked to do?

Should you accept the invitation to participate, you will be asked to compete a short questionnaire regarding the frequency of your videogame play. Following this, you will be presented with detailed instructions for the videogame in this study, *Knight's Tour*. Playing *Knight's Tour* will involve you moving a square around a grid in the shape of a chess "Knight" (two blocks vertical and one block horizontal or vice versa) in an attempt to land on every square on the board no more than once. You will be asked to play the game for as long as you wish, after which time you will be asked to complete a secondary survey questionnaire regarding your experiences and perceptions of the videogame. The research will take place in the psychology department computer lab, and the entire process should take no longer than 50 minutes.

4. Are there any possible benefits from participation in this study?

If you are a first year psychology student, you will receive participation credit for participating. Your participation will also provide you with experience in, and understanding of, the processes underlying scientific research. More generally, research findings will provide greater understanding of videogame design, and provide insight into the mechanisms and theory underlying videogame playing behaviours

5. Are there any possible risks from participation in this study?

There are no foreseeable risks or disadvantages associated with participating in this study.

6. What if I change my mind during or after the study?

That's fine - you are free to withdraw from the study at any time, and without providing an explanation. If you choose to withdraw during the study, your responses will be destroyed. If you complete the study, you will be able to withdraw your data if you choose to do so immediately following completion. Should you wish to withdraw at a later date, you will be able to do so by contacting the researchers and providing them with your identification code (provided on the debrief form after participation).

7. What will happen to the information when this study is over?

All data, including paper-based (e.g., consent forms) and electronic data (stored on password-protected hard drives) will be stored securely in the office of the research supervisor. All data will be stored anonymously, remain confidential, and be accessible by the research supervisor and student investigators only. All data will be stored for a period of five years following thesis publication, after which will be destroyed.

8. How will the results of the study be published?

The results of the study will be published in an academic journal. Once the study has been completed, you will be able to access the results by visiting the website below:
http://www.utas.edu.au/psychology/research/research-project-reports
No individual participants will be identifiable in the publication of the results.

9. What if I have questions about this study?

If you have any questions about this study, please feel free to contact James Sauer via phone on (03) 6226 2051 or email: jim.sauer@utas.edu.au

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H0014954.

This information sheet is for you to keep. If you would like to participate in this study, please ask the researcher for a Consent Form to complete.

Thank you for your attention - your time is very much appreciated.

Appendix G

The Influence of Video Game Features on Video Game Playing Behaviours

Participant Consent Form

1. I agree to take part in the research study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. I understand that the study involves playing a videogame and then answering questions about my gaming experience.
5. I understand that participation involves no foreseeable risks.
6. I understand that all research data will be securely stored on the University of Tasmania premises for five years from the publication of the study results, and will then be destroyed unless I give permission for my data to be archived.

   I agree to have my study data archived. (Note that your data will be stored anonymously.)

   Yes ☐ No ☐
7. Any questions that I have asked have been answered to my satisfaction.
8. I understand that the researchers will maintain confidentiality and that any information I supply to the researcher will be used only for the purposes of the research.
9. I understand that the results of the study will be published so that I cannot be identified as a participant.
10. I understand that my participation is voluntary and that I may withdraw at any time without any effect.

    I understand that I will not be able to withdraw my data after completing the experiment as my data will be anonymous.

Participant's name:
____

Participant's signature:
____

Date: ________________________

Statement by Investigator

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Investigator's name:
____

Investigator's signature:
____

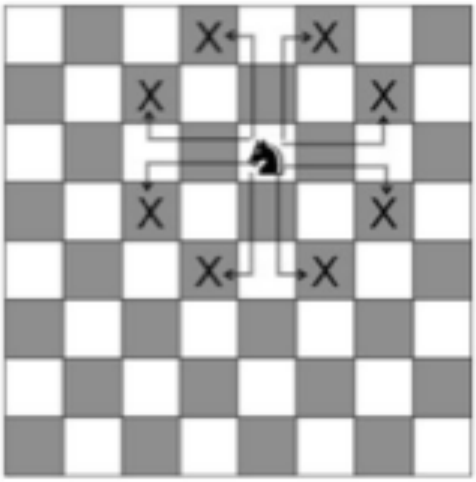
Date: ________________________

Appendix H

KNIGHT'S TOUR

Instructions

Knight's Tour is a chess-based puzzle game. Players are required to move their marker around the chess board, attempting to land on every square without landing on any one square twice. Players are however only able to move in the **'knight' movement pattern** from chess (two squares forward and one to the side), as pictured below:



If there are no moves available the level must be restarted. There are FOUR levels to complete.

- Click **'START'** to begin an attempt.
- Click on any square to start the level.
- If no more moves are available, click **'NEW GAME'** to start the level again.
- Subsequent levels are only available when the ones before it are completed.
- When you are finished, click **'EXIT'** and inform the researcher.

Try to complete all levels but only play for as long as you wish. There are **no time requirements or expectations.**

If you have any questions, don't hesitate to ask the researcher. Otherwise, you are free to begin.

Appendix I

The Influence of Video Game Reinforcement Schedules on Game Play

This study was conducted as part of a fourth year Psychology Honours thesis at the University of Tasmania, and aimed to investigate the effects of structural characteristics within video games on participants' gameplay behaviour, and their perceptions of their gameplay experience.

Particularly, we were interested in how gameplay features like reward mechanisms can influence participants' playing behaviour, and their perceptions of gameplay. The questionnaires completed before the video gaming period measured differences in participants' prior gameplay experience, and allows us test if the effects of game-features vary according to players' prior experiences. A report on the findings of this research will be available following the completion of data collection (i.e., by mid-September), and can be obtained by contacting the researchers on the email addresses provided below.

The researchers ask that if you know somebody who is considering participating in this study that this form is not shared with them as it may potentially jeopardize later results.
James Thomas and Dylan Sault would like to thank you for participating in the current study and potentially contributing to a greater understanding of the structural characteristics within video games and their influences on behaviour.

If you have any further queries about this study, the researchers are happy to answer them now. If you think of questions at a later time, don't hesitate to contact the researchers at:

- jethomas@utas.edu.au
- dmsault@utas.edu.au

And they will be happy to answer any questions you may have.
If for any reason, you wish to have your data removed from the study you can contact either James or Dylan and have your data permanently deleted from the study, by quoting the participant ID number at the top of this page.

Thankyou.